

## CLAIMS

1. A method of determining remaining useful life of a volume of transmission fluid in a vehicle transmission in which portions of the fluid volume are circulated from a transmission fluid sump through operating elements of said transmission including a torque converter and a torque converter clutch, the fluid having known values of remaining useful oxidation life at temperatures experienced in operation of said transmission based on a specified tolerable total increase in acid number (delta TAN), said method being performed by a programmed on-vehicle computer during continual processing cycles of said computer during transmission operation and comprising:
    - (a) measuring the temperature of the volume fraction of fluid, during a time increment, then located in at least one of said sump; torque converter and torque converter clutch;
    - (b) continually subtracting, from a current fluid remaining useful oxidation life value; incremental reductions in remaining useful fluid life due to oxidation during the time increment at the measured temperature of the volume fraction to determine a new fluid remaining useful oxidation life value for use as current fluid remaining useful oxidation life value in the next processing cycle of said computer;
    - (c) continually recording gear shifts executed by said transmission during a time increment and calculating shift energy input to said fluid during said increment;
    - (d) continually subtracting, from a current fluid remaining useful gear shift life value, incremental reductions in fluid remaining useful gear shift life due to current shift energy input to determine a reduced fluid remaining useful gear shift life value for use as current fluid remaining useful gear shift life value in the next processing cycle of said computer; and

- (e) producing an end-of-useful-fluid-life signal when one of the current fluid remaining useful oxidation life value or the current fluid 30 remaining useful gear shift life value reaches zero.

2. The method of determining the remaining useful life of a transmission fluid as recited in claim 1 comprising:

- (a<sub>2</sub>) measuring the temperature of the volume fraction of fluid, during a time increment, then located in said sump and using the temperature 5 of the sump volume fraction to estimate a temperature for the torque converter volume fraction, and
- (b<sub>2</sub>) continually subtracting, from a current fluid remaining useful oxidation life value, reductions in remaining useful fluid life due to oxidation during the time increment at the measured temperature of the sump volume 10 fraction and the estimated temperature of the torque converter volume fraction to determine a new fluid remaining useful oxidation life value for use as current fluid remaining useful oxidation life value in the next processing cycle of said computer.

3. The method of determining the remaining useful life of a transmission fluid as recited in claim 1 comprising:

- (a<sub>3</sub>) periodically measuring the temperature of the volume fraction of fluid, during a time increment, then located in said sump and using the 5 temperature of the sump volume fraction to estimate a temperature for the torque converter volume fraction and a temperature for the torque converter clutch volume fraction, and
- (b<sub>3</sub>) continually subtracting, from a current fluid remaining useful oxidation life value, reductions in remaining useful fluid life due to oxidation 10 during the time increment at the measured temperature of the sump volume fraction and the estimated temperatures of torque converter volume fraction and the torque converter clutch volume fraction to determine a new fluid

remaining useful oxidation life value for use as current fluid remaining useful oxidation life value in the next processing cycle of said computer.

4. The method of determining the remaining useful life of a transmission fluid as recited in claim 1 comprising:

determining an incremental reduction in fluid oxidation life for an increment of time at a reference temperature and providing a look-up table

5 for said on-vehicle computer penalty factors for selected temperatures other than said reference temperature, and

calculating incremental reductions in remaining useful fluid life due to oxidation by applying said penalty factor for the measured or estimated temperature of the fluid volume fraction.

5. The method of determining the remaining useful life of a transmission fluid as recited in claim 2 comprising:

determining an incremental reduction in fluid oxidation life for an increment of time at a reference temperature and providing a look-up table

5 for said on-vehicle computer penalty factors for selected temperatures other than said reference temperature, and

calculating incremental reductions in remaining useful fluid life due to oxidation by applying said penalty factor for the measured or estimated temperature of the fluid volume fraction.

6. The method of determining the remaining useful life of a transmission fluid as recited in claim 3 comprising:

determining an incremental reduction in fluid oxidation life for an increment of time at a reference temperature and providing a look-up table

5 for said on-vehicle computer penalty factors for selected temperatures other than said reference temperature, and

calculating incremental reductions in remaining useful fluid life due to oxidation by applying said penalty factor for the measured or estimated temperature of the fluid volume fraction.

7. The method of determining remaining useful life of a volume of transmission fluid as recited in claim 1 comprising:

- (c) continually recording gear shifts executed by said transmission and transmission sump temperature during a time increment and calculating  
5 shift energy input to said fluid as a function of said sump temperature during said increment.

8. The method of determining remaining useful life of a volume of transmission fluid as recited in claim 1 comprising:

- calculating a total number of gear shifts at a reference transmission sump temperature for an unused transmission fluid for a vehicle  
5 transmission;

(c) continually recording gear shifts executed by said transmission and recording average transmission sump temperature during a time increment;

- continually calculating a reduction in fluid remaining useful gear  
10 shift life at said average sump temperature using a comparison of said sump temperature to said reference temperature; and

- (d) continually subtracting from a current fluid remaining useful gear shift life value, said reduction in fluid remaining useful gear shift life to determine a reduced fluid remaining useful gear shift life for use in the next  
15 processing cycle of said computer.